Manual of Instruction

MODEL 101
Magnetometer

RFL Industries, Inc.
Boonton, New Jersey, U.S.A.

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Magnetometer

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RFL Industries, Inc.
Boonton, New Jersey, U. S. A.

Book No. MA-27400C

CAUTION

FOR YOUR SAFETY

THE INSTALLATION, OPERATION AND MAINTENANCE OF THIS EQUIPMENT SHOULD BE PERFORMED BY QUALIFIED PERSONS ONLY.

WARNING:

The Equipment Herein Described Contains High Voltage

Exercise due care during operation and servicing.
Read safety summary on reverse of this page.

SAFETY SUMMARY

The following safety precautions must be observed at all times during operation, service, and repair of this product. Failure to comply with these precautions, or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the product. RFL assumes no liability for failure to comply with these requirements.

GROUND THE EQUIPMENT

To minimize shock hazard, chassis, cabinets, and equipment racks must be connected to an electrical ground. AC powered products should be equipped with a three-conductor power cable, or equivalent connection on a terminal block. Power cables must either be plugged into an approved three-contact electrical outlet or used with a three-contact or two-contact adapter with the grounding wire (green) firmly connected to an electrical ground (safety ground) at the power outlet. The power jack and mating plug of power cables provided meet International Electrotechnical Commission (IEC) safety standards. Equipment provided with terminal blocks, operating from either ac or dc, is provided with appropriate means for connecting an electrical safety ground.

DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE

Do not operate the product in the presence of flammable gases or fumes. Operation of any electrical equipment in such an environment constitutes a definite safety hazard.

DO NOT OPERATE IN WET OR DAMP AREAS

Do not operate the product in wet or damp areas. Operation of any electrical equipment in such an environment constitutes a definite safety hazard.

KEEP AWAY FROM LIVE CIRCUITS

Operating personnel must not remove covers. Replacement of components and internal adjustments must be made by qualified maintenance persons. Disconnect power cable when replacing components. Under certain conditions, dangerous voltages may exist even with the power cable removed. To avoid injuries always disconnect power and discharge circuits by grounding before touching them.

DO NOT SERVICE OR ADJUST ALONE

Do not attempt internal service or adjustment unless another person capable of rendering first aid and resuscitation is present.

DO NOT SUBSTITUTE PARTS OR MODIFY EQUIPMENT

Because of the danger of introducing additional hazards, do not install substitute parts or perform an unauthorized modification to the equipment. The product may be returned to RFL for service and repair to ensure that safety features are maintained.

DANGEROUS-PROCEDURE WARNINGS

Throughout this manual, warnings identify potentially dangerous procedures. Instructions contained therein must be followed.

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Figure 1. Model 101 Magnetometer

GENERAL

SCOPE OF MANUAL

This manual provides complete operating and maintenance instructions for the Model 101 Magnetometer and pertinent information relating to the fluxgate method of magnetic flux density measurements.

MECHANICAL INSPECTION

The Model 101 Magnetometer is carefully packed to insure against damage from normally rough treatment in transit. Any damage, concealed or otherwise, should be reported immediately to the carrier with a copy to RFL Industries. Please retain cartons and packing material until an investigation of the damages by the carrier or its insurance representative is completed.

ENGINEERING SERVICE

RFL Industries maintains a Magnetic Measuring Applications Engineering Section to provide measuring techniques for individual customer requirements. All application measuring problems, special or routine, are welcomed. Recommendations are made on a composite bases of economy and reliability.

ORDERING INFORMATION

The basic measurement package consists of the Model 101 Magnetometer with battery supply and standard probe (HB-28990). An AC Line Supply (HB-33090) is available.

DESCRIPTION

The Model 101 Magnetometer is a fluxgate type instrument capable of measuring magnetic flux density ranging from a few tenths of a gamma to 10^5 gamma (1 gauss). Coverage is encompassed in ten full-scale ranges of 0 to ±5, ±10, ±50, ±100, ±500, ±1000, ±5000, ±10K, ±50K, and ±100K gamma. Indication of field intensity and polarity is presented on a 4½" taut band meter.

All active circuits are completely solid-state, utilizing transistors and integrated circuits to insure a high degree of stability and reliability. A field compensation circuit is designed into the Probe/Magnetometer to enable observation of variations as small as a few gamma in relatively high ambient fields up to 70,000 gamma. Temperature compensation of the cancellation circuit is provided to assure virtually drift-free operation on a short-term basis.

A calibration check, that may be referred to at any time during operation without disturbing the probe or the Magnetometer Range Switch, is built into the Model 101. The initial calibration is set at the factory using a precision coil having traceability to the National Bureau of Standards.

The Model 101 is housed in a solid walnut case with matching cover and is equipped with a carrying handle. The case also incorporates a slot for storing the sensor when not in use.

The instrument may be operated from a Battery Supply or an optional (HB-33090) 115-230 volt, 50/60 Hz line supply. The battery supply consists of two 6.75 volt mercury batteries having an operation life of approximately 100 hours. An additional mercury battery is incorporated into the basic magnetometer chassis as the field compensation supply. Its life is approximately 500 hours and will last about one year under normal operating conditions.

TABLE 1.
SPECIFICATIONS

Ranges:

±5, ±10, ±50, ±100, ±500, ±1000, ±5000, ±10,000, ±50,000 and ±100,000 gamma.
(1 gamma = 1 x 10^{-5} oersted = 1 nanotesla)

Accuracy:

±7% of full-scale on 100K range, ±5% of full-scale or 1 gamma (whichever is larger) on all other ranges.

Field Compensation:

±70,000 gamma

Field Compensation Resolution:

1 gamma (10,000 gamma field)

Sensitivity:

0.5 gamma

Noise:

0.5 gamma RMS

Power Requirements:

AC Power Supply HB-33090: 115/230 volts, 50/60 Hz

Battery Operation: Two 6.75 volt, 2200 mAH Mercury batteries

Frequency Response:

DC and up to 5 Hz with oscilloscope

Operating Temperature Range:

0 to 45°C

Stability with Temperature (after 10 minute warmup):

Instrument and Probe in Zero Field: < 1 gamma/°C

Field Compensation (w/battery supply): < 0.02%/°C (50,000 gamma field)

Field Compensation (w/AC Power Supply HB-27440): < 0.005%/°C (50,000 gamma field)

Stability with Time (after 10 minute warmup):

Instrument and Probe in Zero Field: < 1 gamma/hour

Field Compensation (w/AC Power Supply): < 0.005% /hour (50,000 gamma field)

Recorder Output:

±30 millivolts into 10,000 ohm load

Probe Remanence:

Less than 1 gamma for an applied field of 1 gauss.

Probe Dimensions:

¾" diameter x 4 7/8" long (1.9 cm x 12.4 cm), with 10 foot (308 cm) cable

Instrument Dimensions:

15¾" wide, 7¾" deep, 9½" high (including cover) (40 cm x 19.5 cm x 24 cm)

Instrument Weight:

13 pounds (5.8 kilograms)

THEORY OF OPERATION

GENERAL

In general, the complete instrument consists of a fluxgate or second harmonic sensor (probe), an oscillator, amplifiers, appropriate filters, an indicating meter and a power supply.

FLUXGATE PROBE

The fluxgate probe (Figure 2) consists of two high-permeable cores, each with its own winding, an output winding and a compensation winding, both common to the core/driven winding section. The cores and their individual windings are arranged adjacent and parallel to each other. In practice, the cores are driven cyclically into saturation by an alternating current having a frequency of 2.5 kHz. When an external magnetic field is present, an EMF consisting of second and other harmonics will be developed in the output winding. The EMF will be proportional to any steady state or slowly varying (less than 5 Hz) ambient magnetic field having a direction parallel to the long axis of the probe cores. In operation, all signals other than the second harmonic are attenuated in the magnetometer circuitry. The tertiary winding is provided to allow cancellation of the ambient field where desired, in order that perturbations in the field may be observed and measured to a high degree of precision. The polarity of the cancellation field and its amplitude is controlled by means of a switch and potentiometers located on the Model 101 instrument panel.

MAGNETOMETER

The generalized sections of the Model 101 are shown in block diagram form in Figure 3. A balanced push-pull oscillator doubler circuit generates the driving current which is supplied to the fluxgate probe through a matching transformer. The oscillator is designed for minimum harmonic generation; any second harmonic would tend to present an error signal to the probe. Amplitude control is effected by means of a current sensing circuit. A frequency doubling circuit is incorporated into the oscillator and serves a two-fold purpose: the 5 kHz signal is amplified and drives the ring demodulator (phase detector) and it is applied through a phase shifting network to provide the internal calibration self-check.

The fluxgate probe 5 kHz output signal (in the presence of an ambient field) is filtered and applied to the attenuator (Range Selector) through an FET source follower. The 5 kHz filter is a three-pole Butterworth type with attenuation characteristics in excess of 60 dB at 1.5 x the passband center. The resultant signal is then amplified by an integrated circuit and applied to the detector through a driver transistor. The dynamic range of the I. C. driver transistor enables a high degree of linearity to be achieved in the output indicator (meter).

A ring demodulator, which functions as an amplifier sensitive detector, is used to sense the phase displacement

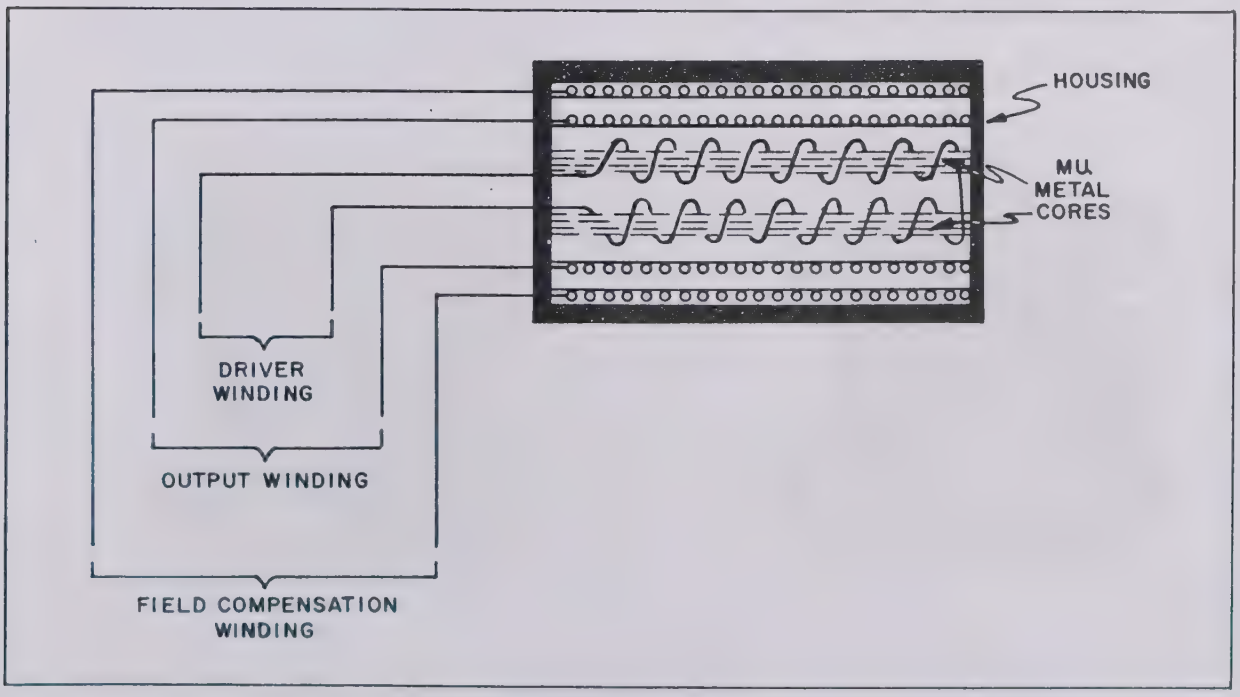


Figure 2. Fluxgate Probe

between the 5 kHz reference signal and the 5 kHz EMF generated by the fluxgate probe. Under no signal conditions (absence of an ambient magnetic field) no even harmonics are generated and thus no current will flow in the rectifier circuit, resulting in zero meter indication. The shift to out-of-phase condition which is proportional to the amplitude of the ambient field applied to the fluxgate probe and will cause current to flow in the rectifier circuit resulting in appropriate meter deflection with polarity of indication dependent on the phase quadrant.

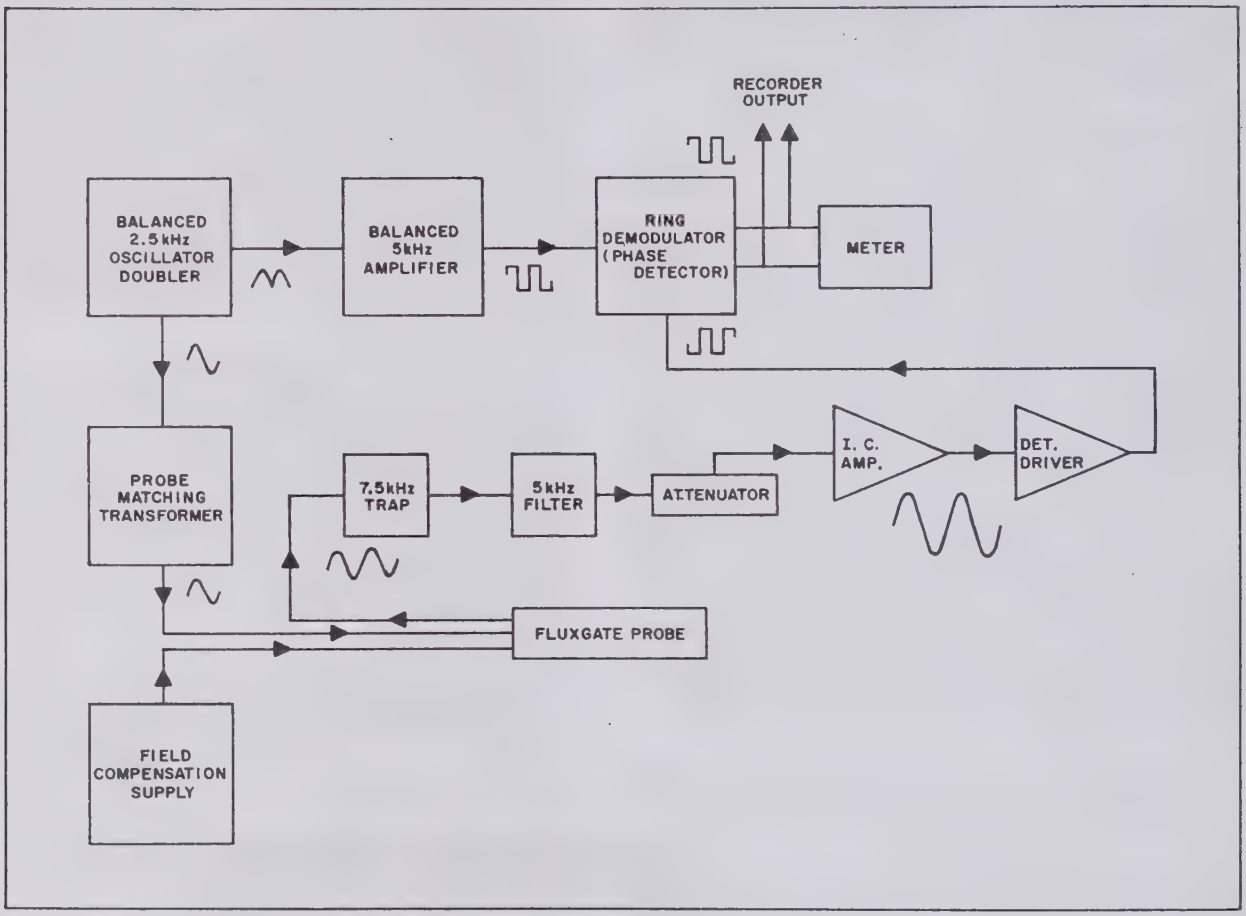


Figure 3. Block Diagram of Model 101 Magnetometer and Fluxgate Probe

OPERATIONAL PROCEDURE

INITIAL SET-UP

The Model 101 Magnetometer is shipped with the appropriate power supply installed, either battery or line supply, depending on the buyer's ordering information. If both supplies are ordered, the instrument will have the AC line supply installed with the battery supply packed separately. CAUTION: The AC line supply can be set for either 115 or 230 volt operation. Check the tag attached to the supply to verify that factory line connections are appropriate to the AC line which will be used.

The supplies are subassemblies of the main chassis of the instrument. Battery supplies are shipped with the batteries packed separately. They must be inserted into their holders on the main assembly.

NOTE

Be certain to install batteries with polarity as indicated by the markings adjacent to the holders. Serious damage can result if reverse polarity is applied to the instrument.

Figure 4 depicts the battery assembly section of the chassis assembly showing the correct placement of batteries with regard to polarity. The AC line supply is shown in Figure 5. Connections for 115 or 230 volt line are shown in the schematic diagram. The line cord for the AC supply is a three conductor cable. It is normally stored in the left-hand storage compartment with the probe.

CHANGING INSTRUMENT FOR 110V/220V AC, 50/60 Hz OPERATION

A. Disconnect the red, orange, and blue leads from the battery power supply assembly. Disconnect the yellow and blue leads from the printed circuit board.

B. Remove the battery supply assembly from the chassis assembly and install the AC Supply HB-33090 in its place as indicated in Figure 5. Be sure to position the printed circuit board with the fuse towards the front panel.

C. Connect red, orange, blue, purple, and yellow leads to the color coded terminals on the printed circuit board.

D. Connect black and white leads of line cord assembly to terminals labeled black and white on P.C. board. Connect green lead to the grounding lug which is mounted on the rectangular bar next to the RANGE switch.

E. Mechanically secure the line cord with a cable clamp mounted on the rectangular bar between the FIELD COMPENSATION switch and the PROBE receptacle.

F. The line cord is fed through the slot in the partition in the case, and is stored in the storage compartment when the instrument is not in use.

G. Due to small differences between voltages for AC line and battery operation, slight calibration adjustment may be required. If the unit does not make full-scale calibration in the CALIBRATE mode of operation as it did with the battery power supply, then refer to the TEST PROCEDURE section on SETUP AND CALIBRATION for the required adjustment.

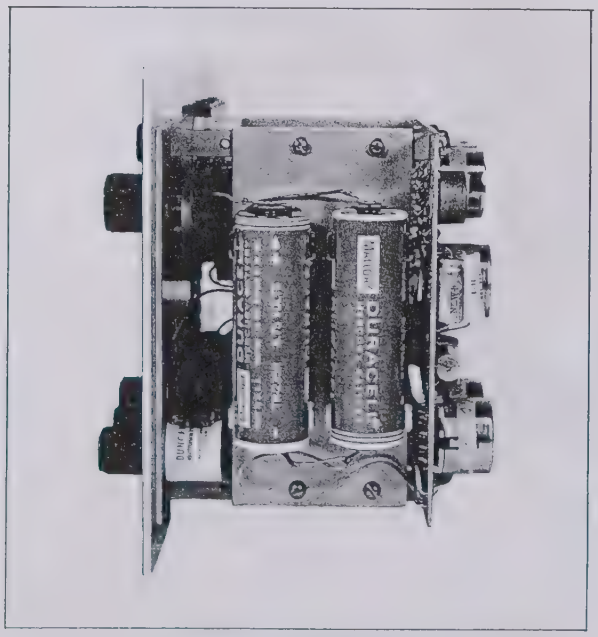


Figure 4. Battery Supply

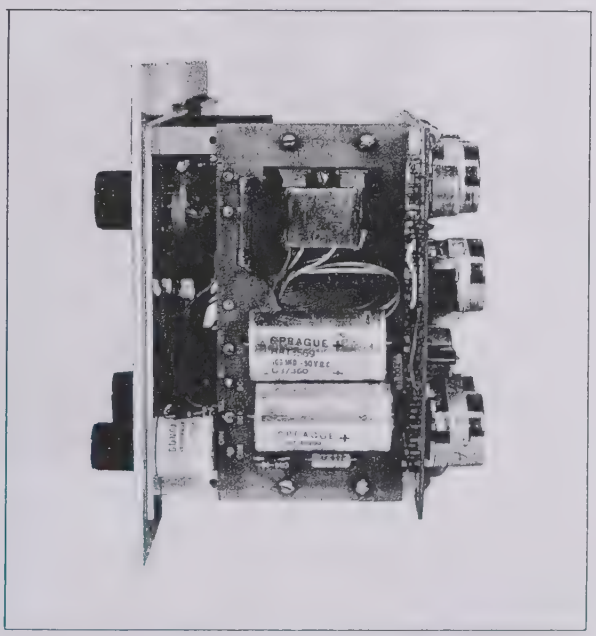


Figure 5. AC Line Supply

PRELIMINARY OPERATION

Prior to placing the EQUIPMENT switch to the ON position, set the front panel controls as follows: RANGE selector to CHK, OPERATE-CALIBRATE switch to OPERATE, FIELD COMPENSATION switch to OFF. Connect fluxgate probe to PROBE receptacle.

Place EQUIPMENT switch to ON position. Meter should deflect with pointer coming to rest in the green area of scale marked PWR. CHK. This indicates the batteries (if used) are in satisfactory condition and that supply voltage is normal.

Place RANGE selector to 100K position. Meter should deflect down toward zero, coming to rest near zero or to an indication commensurate with ambient magnetic field (see Table 2 for a guide to the flux density indication which may be expected for various angular positions of the probe).

Place OPERATE-CALIBRATE switch to the CALIBRATE position. Meter should deflect toward the portion of the scale marked CAL. Rotate CALIBRATE ADJUST control until meter pointer rests at the apex of the green CAL point on the scale. Return OPERATE-CALIBRATE switch to OPERATE position. When the Model 101 is used as a battery powered unit it is advisable to allow several minutes for warm-up prior to setting the calibration adjustment. This allows the batteries to stabilize to their normal working level with a resulting higher degree of calibration stability.

The instrument is now ready to use for the measurement of absolute flux density or absolute variations in flux density in any ambient steady state or slowly varying magnetic field.

INTERNAL ADJUSTMENT

When a probe is replaced or interchanged, it may be necessary, in some instances, to adjust the tuning slug of transformer T101. This is only required if meter deflection does not reach CAL point when adjusting the Model 101 Calibration Control. This, of course, assumes the equipment batteries are in operating condition.

Adjustment Procedure:

1. Remove the four BHMS from the front panel and remove chassis from the case.
2. Place CAL-OPERATE switch to CAL position. Set CALIBRATION ADJ control to center of its rotation.
3. Adjust tuning slug in T101 (see Figure 6) for maximum meter deflection toward CAL point.

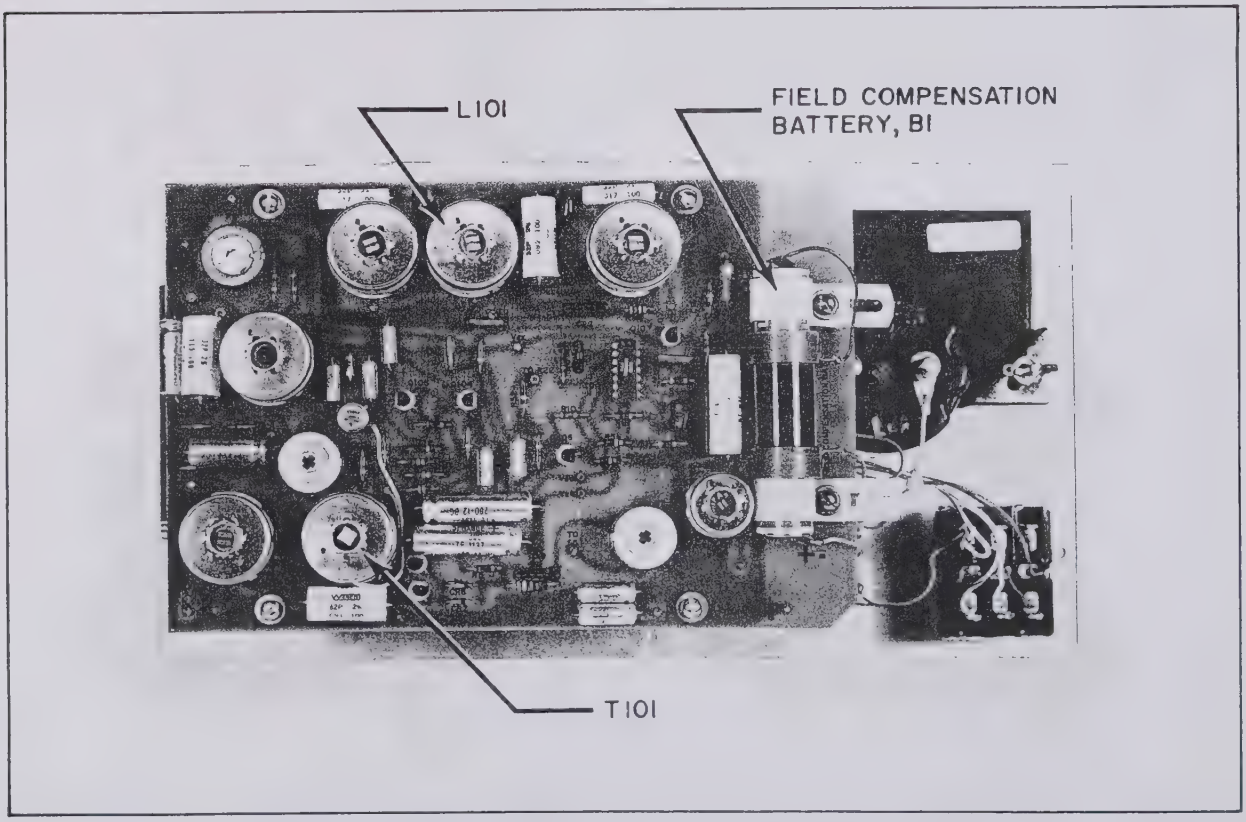


Figure 6. Rear View Depicting Tuning Slug for Internal Adjustment

MEASUREMENTS

MEASUREMENT TECHNIQUE USING FIELD COMPENSATION CAPABILITY

Set Model 101 to measure absolute flux density as described in the preceding section, Preliminary Operation. Note flux density and polarity of field as indicated on the Model 101 meter. Set the FIELD COMPENSATION FINE controls to their maximum clockwise rotation (each control is a ten-turn potentiometer). Set the FIELD COMPENSATION COARSE control to a value equal to or slightly higher than the field indicated on the meter. The COARSE control has a range of 3000 gamma to 70,000 gamma in 3000 gamma steps. For example: If the indicated field has a value of 20,000 gamma, the COARSE control should be set to the cardinal point marked 24 or the next point lower (i.e. 21). Do not set the COARSE control to a value lower than that commensurate with the indicated field. Set the FIELD COMPENSATION +OFF; switch to the same polarity as that indicated by the meter.

Adjust FINE controls for meter zero indication. Increase Magnetometer sensitivity by placing RANGE selector to lower full-scale sensitivity positions, meanwhile adjusting FINE controls for meter zero indication.

NOTE

The sensitivity of adjustment of the controls may appear to vary as their rotational position is changed. This is normal and is caused by the change in current through the compensation winding as the control resistance is increased or decreased.

Make final compensation adjustment at a range compatible with the sensitivity expansion desired. In the above example (absolute field of 20,000 gamma) assume it is desirable to observe perturbations on the order of 50 gamma. In this case either the 100 gamma or 500 gamma full-scale range could be used.

PHYSICAL STABILITY OF PROBE

When operating in the expanded sensitivity mode (using field compensation) it is important that the probe be kept in a stable physical position. Any slight angular movement of the probe, will in effect, place it in a different ambient field, and where a high sensitivity expansion is in effect, will result in off-scale deflection of the meter. This deflection will not be harmful to the instrument but would require rebalancing of the FIELD COMPENSATION controls. Where it is desirable to search for anomalies in a given ambient field, the expanded sensitivity may be used if the probe is kept in its original angular position in respect to the vertical and horizontal plane.

EFFECTS OF MAGNETIC BODIES DURING MEASUREMENTS

Any ferrous or magnetic bodies will affect the gradient of the magnetic field being measured. A change in gradient, if it is sufficiently large, will in turn affect the absolute flux density of the area being measured. As an example, an automobile moving a distance of 100 feet from the probe will cause a change of about 50 gamma in the ambient field. Change of position of a steel file cabinet drawer (open to close) can cause a change as great as 500 gamma at a distance of 3 feet from the probe.

Steel chairs can cause changes of many hundreds of gamma with change of their position. At the highest sensitivity ranges, steel nails in shoes can cause gradients in the field. Where measurements of high order sensitivity expansion are to be performed, the operator should consider the effects of any ferrous bodies within a range of twenty feet or so of the probe. This is especially true where it is possible the bodies may be moved during the course of the measurements. Electromagnetic influences should also be investigated where precision measurements are concerned. Relays and telephone crossbar switching devices can cause gross changes in ambient magnetic fields when changing from their energized or de-energized conditions.

TABLE 2.
FLUX DENSITY GUIDE IN EARTH FIELD

Probe Orientation	Magnetometer Reading (Gamma)
Horizontal (North-South)	21,000
Horizontal (East-West)	0
Vertical	50,000

NOTE: The figures given above are typical for the Northern New Jersey area. Earth field measurements should be monitored in a relatively gradient-free location in order to avoid errors caused by neighboring ferrous objects or ore bodies.

TEST PROCEDURE

TEST EQUIPMENT REQUIRED

Multimeter – Simpson Model 270 (or equivalent)

Variable Voltage Power Supply – Hewlett Packard Model 6200 (or equivalent)

Oscilloscope – Tektronix 533 (or equivalent)

Frequency Counter – Hewlett Packard Model 5211A (or equivalent)

Neutral Chamber – Perfection Mica ZG101 (or equivalent)

Solenoidal Coil – Mounted in Chamber (1 amp/gauss or other suitable CAL constant)

A. SETUP AND CALIBRATION

1. Before energizing instrument, check for shorts of the Vcc and Vee line. Use Simpson 270 Rx100 scale with negative P. C. board ground.

   Vee not less than 7.0K ohms
   Vcc not less than 15.0K ohms

2. Make sure meter is at mechanical "zero" and switch in "operate."

3. Insert Magnetometer probe into socket.

4. Position probe in neutral chamber. (Perfection mica ZG101 or equivalent with coil.)

5. With field compensation switch in OFF, position neutral chamber for lowest ambient field.

6. Flip switch to either + or - and cancel the ambient field (0 gamma) if necessary.

7. Now set RANGE-GAMMA switch to 100 and pass +1mA through the coil. The meter should read positive full scale. If not, turn ADJUST clockwise for full-scale deflection.

8. Should the ADJUST not make full-scale:
   a. Attach frequency counter to collector of Q101 and common.
   b. Adjust T101 for 2550 ±10 Hz.
   c. If necessary, adjust L101 for max. scale deflection.

9. Repeat step 7 and flip OPERATE-CALIBRATE switch to CALIBRATE.

10. Adjust R2 so needle will be at CAL mark.

11. Check electrical zero in OPERATE position. Adjust R8 as required.

12. Check for oscillator ampltiude regulation; make sure meter is at zero on 100 gamma scale. Use 100 gamma signal for this test and a variable voltage DC supply center tapped.

    Supply at 13.5 volts and scope at one side of R46 & T101, a distorted sinewave of 1.2V p-p must be observed. If more or less than 1.2V p-p, adjust R47 for 1.2V p-p. Recheck frequency of 2550 ±10 Hz at C26 & common.

    Now reduce supply to 10 volts. The meter reading will be less than 100 gamma. Adjust L101, R47 for max. deflection. As long as the ADJUST control will make slightly over full-scale, the operation is normal. Between 10V and 13.5V, the oscillator amplitude should be 1.2V p-p.

13. Check tracking of CAL signal with 100 gamma fields; make sure meter is at zero on 100 gamma scale. At 13.5 volts supply and 100 gamma full-scale field, flip to CALIBRATE and adjust R2 for full-scale. Reduce supply to 10 volts. Flip switch to OPERATE and observe meter reading. Flip switch to CALIBRATE. Calibration reading should be within 5% of operate reading.

B. LINEARITY MEASUREMENTS

1. Repeat Item A. 1 through 6.
2. With coil current of 50 uA, meter should read 5 gamma full scale.
3. Turn RANGE-GAMMA switch to 10 and observe ½ scale deflection or 5 gamma.
4. Increase coil current to 100 uA and meter should read full scale or 10 gamma.
5. Turn RANGE-GAMMA switch to 50, read 10 gamma.
6. Coil current to 0.5 mA, meter full scale.
7. RANGE-GAMMA switch to 100, read ½ scale.
8. Coil to 1 mA, read full scale.
9. RANGE-GAMMA switch to 500, read 100 gamma.
10. Coil to 5 mA, read full scale.
11. RANGE-GAMMA switch to 1K, read ½ scale.
12. Coil to 10 mA, read full scale.
13. RANGE-GAMMA switch to 5K, read 1K gamma.
14. Coil to 50 mA, read full scale.
15. RANGE-GAMMA switch to 10K, read ½ scale.
16. Coil to 100 mA, read full scale.
17. RANGE-GAMMA to 50K, read 10 gamma.
18. Coil to 500 mA, read full scale.
19. RANGE-GAMMA to 100K and read ½ scale.
20. Keep high coil current on as short as possible. Reduce current gradually, not abruptly.

C. FIELD COMPENSATION TEST

1. Determine residual (ambient) field in chamber. This should indicate about 20-150 gamma.

2. RANGE-GAMMA switch to 10K. Put +30 mA into coil, FIELD COMPENSATION switch in OFF position. A reading near 3K should occur.

3. Flip FIELD COMPENSATION switch (FCS) to positive, since the field is positive and set COARSE to next line counterclockwise from 6.

4. With both fine controls in extreme clockwise position, the meter should be "zeroed" within ½ meter division.

5. Put +60 mA in coil, FCS in OFF position. Note 6K reading.

6. With FCS in positive position, turn COARSE to 6. Meter zero should be within 2 divisions.

7. Put 90 mA in coil, COARSE to the next position clockwise from 6 and meter zero should be near 2 divisions.

8. RANGE-GAMMA switch to 50K and 300 mA into coil.

9. COARSE set to 30 and meter should zero within 1 division.

10. For negative fields, reverse supply wires and repeat 1 through 9.

D. REPLACEMENT OF FIELD COMPENSATION BATTERY

1. Unsolder violet and green wires from battery tabs.

2. Loosen the two screws on nylon battery holders.

> Use caution when working in the area of the compensation coil, which is around the battery, as it is a precision component and may be easily damaged.

3. Slide used battery out and install replacement.

4. Tighten the two screws on nylon battery holders so battery is held firm.

5. Resolder violet wire to negative terminal and green wire to positive terminal of battery.

After replacement battery is installed, check for proper operation as indicated in Measurements Section.

Table of Replaceable Parts

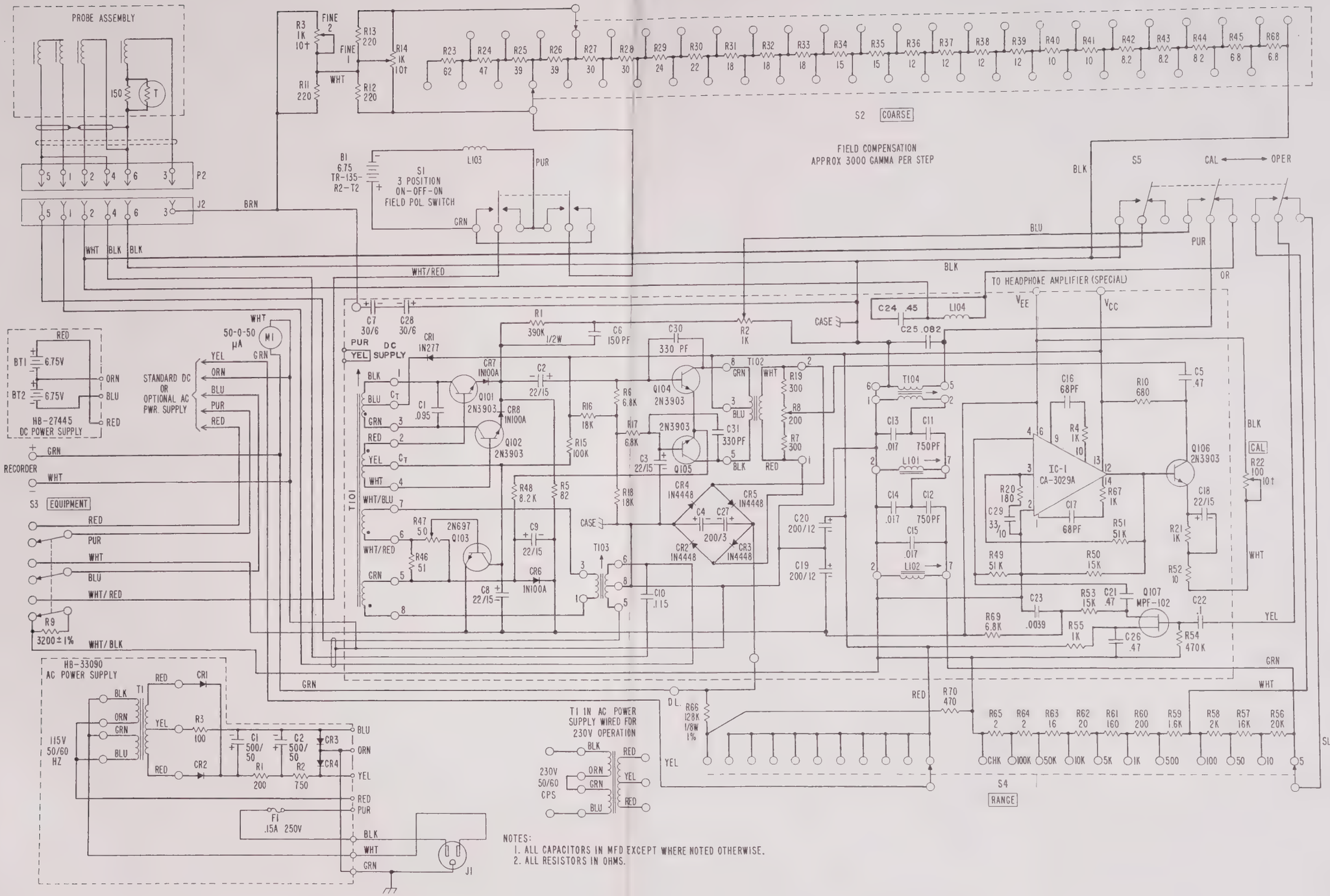
DIAGRAM SYMBOL	NAME OF PART AND DESCRIPTION	RFL PART NO.
B1	BATTERY, mercury: 6.75V, 1000mAH	HA-27424
BT1, 2	BATTERY, mercury: 6.75V, 2200mAH	HA-23807
C1	CAPACITOR, polystyrene: 0.095μF 2%, 100V	H-5115-81
C2, 3, 8, 9, 18	CAPACITOR, tantalum: 22μF 20%, 15V	H-1007-656
C4, 27	CAPACITOR, electrolytic: 200μF 20%, 3V	HB-12970
C5, 21, 26	CAPACITOR, ceramic: 0.47μF +80 -20%, 25V	HA-13579
C6	CAPACITOR, silver mica: 150 pF 2%, 500V	HA-16608
C7, 28	CAPACITOR, electrolytic: 30μF 20%, 6V	H-1007-924
C10	CAPACITOR, polystyrene: 0.115μF 2%, 100V	H-5115-93
C11, 12	CAPACITOR, silver mica: 750 pF 2%, 300V	H-1080-346
C13	CAPACITOR, polystyrene: factory adjust	
C14, 15	CAPACITOR, polystyrene: 0.017μF 2%, 100V	H-5115-46
C16, 17	CAPACITOR, silver mica: 68 pF 5%, 500V	HA-16518
C19, 20	CAPACITOR, electrolytic: 200μF +75 -10%, 12V	H-1007-652
C22	CAPACITOR, mylar: 0.1μF 10%, 50V	H-1080-304
C23	CAPACITOR, film: 0.0039μF 10%, 200V	H-1007-680
C24	CAPACITOR, polystyrene: 0.45μF 2%, 100V	H-1007-447
C25	CAPACITOR, polystyrene: 0.082μF 2%, 100V	H-5115-79
C29	CAPACITOR, tantalum: 33μF 20%, 10V	H-1007-653
C30, 31	CAPACITOR, ceramic disc: 330pF 10%, 500V	H-1007-1270
CR1	DIODE, germ.: 1N277	HA-23804
CR2-5	DIODE, silicon: 1N4448	HA-29074
CR6, 7, 8	DIODE, germ.: 1N100A	HA-28507
IC1	INTEGRATED CIRCUIT	H-0620-1
L101	INDUCTOR ASSEMBLY	HB-27407
L102	INDUCTOR ASSEMBLY	HB-27426
L103	INDUCTOR ASSEMBLY	HB-27433
L104	INDUCTOR ASSEMBLY	HB-27444
M1	METER, 50-0-50μA	HC-27408
Q101, 102, 104-106	TRANSISTOR, 2N3903	HA-21562
Q103	TRANSISTOR, 2N697	HA-18598
Q107	TRANSISTOR, MPF-102	HA-26583

Table of Replaceable Parts

DIAGRAM SYMBOL	NAME OF PART AND DESCRIPTION	RFL PART NO.
R1	RESISTOR, fixed comp: 390K ±5%, ½W	H-1009-427
R2	RESISTOR, variable: WW, 1000 ohm	HA-12587
R3, 14	RESISTOR, variable: WW, 10 turn 1K ±5%, 2W	HA-27422
R4, 55, 67	RESISTOR, fixed comp: 1K ±10%, ¼W	H-1009-725
R5	RESISTOR, fixed comp: 82 ohm ±5%, ¼W	H-1009-835
R6, 17, 69	RESISTOR, fixed comp: 6.8K ±10%, ¼W	H-1009-741
R7, 19	RESISTOR, fixed comp: 300 ohm ±5%, ¼W	H-1009-841
R8	RESISTOR, variable: WW, 200 ohm	HA-21206
R9	RESISTOR, WW, 3.2K ±1%, 1W	H-1780-26
R10	RESISTOR, fixed comp: 680 ohm ±5%, ¼W	H-1009-754
R11, 12, 13	RESISTOR, fixed comp: 220 ohm ±10%, ¼W	H-1009-766
R15	RESISTOR, fixed comp: 100K ±5%, ¼W	H-1009-795
R16, 18	RESISTOR, fixed comp: 18K ±10%, ¼W	H-1009-744
R20	RESISTOR, fixed comp: 180 ohm ±5%, ¼W	H-1009-764
R21	RESISTOR, fixed comp: 1K ±5%, ¼W	H-1009-612
R22	RESISTOR, variable, comp: 100 ohm, 0.3W	HA-30752
R23	RESISTOR, fixed comp: 62 ohm ±5%, ¼W	H-1009-942
R24	RESISTOR, fixed comp: 47 ohm ±5%, ¼W	H-1009-832
R25, 26	RESISTOR, fixed comp: 39 ohm ±5%, ¼W	H-1009-831
R27, 28	RESISTOR, fixed comp: 30 ohm ±5%, ¼W	H-1009-828
R29	RESISTOR, fixed comp: 24 ohm ±5%, ¼W	H-1009-827
R30	RESISTOR, fixed comp: 22 ohm ±5%, ¼W	H-1009-613
R31, 32, 33	RESISTOR, fixed comp: 18 ohm ±5%, ¼W	H-1009-930
R34, 35	RESISTOR, fixed comp: 15 ohm ±5%, ¼W	H-1009-825
R36, 37, 38, 39	RESISTOR, fixed comp: 12 ohm ±5%, ¼W	H-1009-824
R40, 41	RESISTOR, fixed comp: 10 ohm ±5%, ¼W	H-1009-823
R42, 43, 44	RESISTOR, fixed comp: 8.2 ohm ±5%, ¼W	H-1009-971
R45, 68	RESISTOR, fixed comp: 6.8 ohm ±5%, ¼W	H-1009-901
R46	RESISTOR, fixed comp: 51 ohm ±5%, ¼W	H-1009-818

Table of Replaceable Parts

DIAGRAM SYMBOL	NAME OF PART AND DESCRIPTION	RFL PART NO.
R47	RESISTOR, variable: WW, 50 ohm	HA-11264
R48	RESISTOR, fixed comp: 8.2K ±10%, ¼W	H-1009-883
R50, 53	RESISTOR, fixed comp: 15K ±5%, ¼W	H-1009-816
R49, 51	RESISTOR, fixed comp: 51K, ±5%, ¼W	H-1009-774
R52	RESISTOR, fixed comp: 10 ohm ±10%, ¼W	H-1009-736
R54	RESISTOR, fixed comp: 470K ±10%, ¼W	H-1009-974
R56	RESISTOR, metal film: 20K .25%, 1/10W	H-1510-986
R57	RESISTOR, metal film: 16K .25%, 1/10W	H-1510-985
R58	RESISTOR, metal film: 2K .25%, 1/10W	H-1510-984
R59	RESISTOR, metal film: 1.6K .25%, 1/10W	H-1510-983
R60	RESISTOR, metal film: 200 ohm .25%, 1/10W	H-1510-981
R61	RESISTOR, metal film: 160 ohm .25%, 1/10W	H-1510-982
R62	RESISTOR, WW: 20 ohm .25%, 1W	H-1780-23
R63	RESISTOR, WW: 16 ohm .25%, 1W	H-1780-24
R64, 65	RESISTOR, WW: 2 ohm .25%, 1W	H-1780-25
R66	RESISTOR, metal film: 128K, ±1%, 1/8W	H-1510-887
R70	RESISTOR, fixed comp: 470 ohm ±5%, ¼W	H-1009-751
S1	SWITCH, toggle: On-Off-On, DPDT	HA-31713
S2	SWITCH, 2-pole: 24 pos., 2 sect.	HC-27417
S3	SWITCH, toggle: 3 PDT	HA-21632
S4	SWITCH, assy. range	HC-27431
S5	SWITCH, toggle: 3 PDT	HA-26126
T101	TRANSFORMER Assy.	HB-27406
T102	TRANSFORMER Assy.	HB-23812
T103	TRANSFORMER Assy.	HB-27428
T104	TRANSFORMER Assy.	HB-27427



Schematic Diagram of RFL Model 101 Magnetometer

Warranty

The Model 101 Magnetometer carries a warranty of 12 months from date of delivery for replacement of any part which fails during normal operation or service. Deficient parts should be returned to the factory, shipping charges prepaid, for replacement f. o. b. Boonton, N. J.

RFL Industries, Inc.

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